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Perceptual-Motor Adaptation in Laparoscopic Surgery

Adaptação Perceptivo-Motora na Cirurgia Laparoscópica

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ABSTRACT

In the face of experience with the training center in video-surgery of Recife, based by specific literature, is considered the physiology of human perception and perceptual changes, found in laparoscopic surgery, being provided guidelines to facilitate the work in these new perceptual circumstances. It is concluded by the need for change in the structure of teaching this surgical approach characterized by an initial period of adaptation to the new environment perceptual-motor created, followed by the transposition of the learning curve of each procedure to be run.

Key words: Learning. Perception. Motion. Surgery. Laparoscopy. Video-assisted surgery.

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Basic courses on laparoscopic surgery, conducted at the Videosurgery Training Center of Recife in the 1990s, allowed us to observe *trainees* overcoming the challenges arising from the execution of movements, through ports in an environment perceived by two-dimensional vision and limited haptic sensation. This difficulty of perceptual-motor adaptation in the manipulation of structures seen on a video monitor, led us to seek, in the relevant literature, a comprehension of several issues fundamental to its understanding:

a) How do human beings perceive the world around them

b) What changes in perception occur in laparoscopic surgery

c) Adaptation of manipulation in this new perceptual environment

HUMAN PERCEPTION

Perception is a human brain function that assigns meaning to sensory stimuli based on previous experiences.[1] Human beings use the brain to organize and interpret the sensory information arriving from its surroundings and from its own body, assigning meaning to this information. Perception is viewed by SEKULER and BLAKE as a biological process whereby the information captured by the sensory nervous system is analyzed by the perceptual process, so that one can interact with the world, facilitating the planning of appropriate attitudes or movements, although with limitations.[2,3] It is understood that perception is not that same as reality, but is its representation.[4] Selective attention determines a range of perception subject to external and internal factors, of which motivation, experience, and emotion are extremely important.[5]

Charles Sherrington, an English neurophysiologist, classified the senses as surface (or exteroceptive), deep (or proprioceptive), and visceral (or intraceptive). The surface senses (vision, hearing, taste, olfaction, and touch) are each related to specific organ, the deep senses depend on existing specialized sensors in the muscles, tendons and joints, while the visceral sensations are latent, only perceived when the organs are diseased.[6]

Kinesiology, the science which studies how humans move, uses the same classification, dividing the perception of movements into proprioceptive and exteroceptive. Proprioception is the ability of humans to perceive the position and movement of their bodies in space, while exteroception evaluates the position of objects around them, a function carried out by vision.[7]

Proprioception depends on mechanoreceptors present in the muscle spindles that inform which muscle groups are contracted or relaxed; on neurosensors present in joints that indicate the angle of each one of them; and on Golgi bodies, specialized sensors located in the tendons, which detect the traction exerted on the tendons.

These three groups of sensors are responsible for kinesthetic perception, and when combined with tactile sensation captured by specialized sensors located in the skin – especially the skin of the hands – establish haptic sensation, which can inform not only tactile sensation, but also other characteristics of palpated objects, including their consistency, shape, and spatial location.[8]

Therefore, haptic perception promotes knowledge of the surroundings perceived by sensory receptors in the skin, muscles, tendons and joints, involving an active exploration.[9] Following vision, haptic perception is the second most reliable that human beings have to perceive the space in which find themselves, safely analyzing their location and movement (navigation) in this space.[10]

The vestibular system located in the inner ear is also essential to proprioception, and is responsible for our body's equilibrium. This system contributes to the vestibular-ocular reflex by automatically sending stimuli to effect changes in the muscles responsible for eye movements, stabilizing the image on the retina, including keeping the horizon in a static position, thereby facilitating the spatial orientation.[11]

Within the near-body space (or micro-space) – which corresponds to that space that can be manipulated – egocentric distance (depth) is measured very accurately by binocular convergence (up to 6 meters) and by visual accommodation (up to 3 meters). With binocular vision each eye captures the image of the object in a particular axis, forming an angle between the two axes as they converge on the object. With this, the brain calculates the distance between the observer and the observed object. With the visual accommodation, contraction of the ciliary muscle generates greater or lesser curvature of the lens in order to focus on the observed object. This muscle contraction is perceived by the brain allowing/ permtting it to calculate the distance of the observed object.[12]

In the image projected on the monitor, all the objects or structures are seen in a single plane, rendering binocular convergence and visual accommodation ineffective. In such circumstances, human beings use monocular visual pr pictoral cues to assess depth. Relative size, convergence (or perspective), the known size, what objects are obscured (or overlapped) by others, and the vision in the horizontal plane provide a limited sense of the depth, while shadows, texture, brightness or sheen, and contrast (or aerial perspective), which depend crucially on the brightness and image quality, provide a slightly more precise assessment of depth (egocentric distance).[13,14] For this reason, the surgeon better pereceives depth (the 3rd dimension) when working in well-lit areas and with the image captured and projected by a high resolution system.

As previously stated: "perception does not correspond to reality", varying depending on the environment or working space as well as subjective factors. The perceived visual space is the mental representation of the environment within its geometrical properties. In the real physical (or experiential) space, in the peripersonal area, egocentric distance is overestimated varying with the angle and increasing with age, due to a phenomenon called "superconstancy. In the virtual physical space (of the computer) and in the pictorial (or photographic) space, which is the image projected as video, depth is underestimated.[15] This is why during a laparoscopic procedure we always try to clamp a structure or grab a suture before reaching it.

From birth children experience everything through their senses; they explore their surroundings, especially through physical activity, initially by crawling, walking, jumping, and then through play, games, gymnastics, dance, sports, etc. These activities lead to the development of spatial orientation and its relation to the time needed to carry out movements in space. The construction of three-dimensional space, and the internalisation of the properties of space, accompany motor development.[16] These motor experiences during childhood, are responsible for the development of spatial orientation and navigation.[17] Obviously, failures or restrictions during this period of evolution will bring harmful consequences to future motor learning.

PERCEPTION IN LAPAROSCOPIC SURGERY

Unlike open surgery, where the experiential space is expanded inside the patient through a generous incision, in laparoscopic surgery the maintenance of the mucocutaneous barrier, determines the need to create two interfaces: a visual interface to promote a view of the body cavity to be manipulated during the operation, and a motor interface to permit its manipulation. Furthermore, it is imperative, that the peritoneal cavity, which is virtual, be transformed into a real space, to create an open area, suitable for viewing and manipulation.[18]

To establish this space the surgeon will have to learn how to access the peritoneal cavity, define which gas to use to create the appropriate environment, what pressure to maintain, and the local and general repercussions arising from this pressure, occasional leaks, or any absorption of the gas, as well as the possibility of leaks from the circuit due to the use of electric current newly created environment. The surgeon should also master how to use gravity to displace viscera and understand the importance of an adequate muscle relaxation for the maintenance of that space, a responsibility of the anesthesiologist.

The most important and challenging for the *apprentice* of laparoscopic surgery, however, is the need to experience a perceptual-motor adaptation in an environment similar to that found in this surgical approach. This can be done through the use of: inanimate simulators (black box), experimental animals, fresh cadavers, or virtual simulators. The surgeon needs to adapt to working in an environment of perception distinct from the usual, with perceptual limitations, imposed by the creation of two interfaces (visual and motor) necessary for the procedure.

The visual interface, which requires that light reaches the peritoneal cavity and of the illuminated image to be observed on the monitor be captured, divide the surgical space into: the projected space (that which is seen on the monitor) and a blind space (not seen in the projected image). In fact, the surgeon is operating in three environments with distinct visual perceptions:

a) In the living space, perceived in three dimensions, when you move outside the abdominal cavity, inserting or removing the surgical instruments through the ports.

b) In the projected space, perceived in two dimensions, when manipulating intracorporeal visceral structures seen on the video monitor.

c) In the blind space, an area without any visual dimension (zero dimension) as visceral traction is applied outside of the view captured by the camera (most of the time handled by an assistant).

The motor interface consists of the trocars which allow the passage of instruments through the abdominal wall without leakage of the pneumoperitoneum. The rubberized valves, however, reduce the haptic perception of the surgeon by about 50%. This motor interface also creates a *fulcrum* effect, which corresponds to mirrored movement, such that there is an opposite movement within the body in relation to those executed by the surgeon's hand outside of the patient's body. This fulcrum effect also modifies the force resulting from manuvering the instruments, much as like a lever, depending on the length of the instrument outside the cavity.

Manipulation of the optic by another person (the camera operator) precludes the vestibulo-ocular reflex, responsible for equilibrium, maintenance of the horizon in its proper place, and actions to follow the object in motion. The assistant who manuevers the camera should maintain the horizon and follow the movements of the surgeon, maintain the structure to be manipulated in the center of the monitor. In addition, the camera operator should learn to use the angulation of the optic to produce an oblique view, while maintaining the horizon and the centralization of the structure being manipulated. The camera operator should also widen the viewing area by retracting the optic whenever the surgeon withdraws or inserts an instrument into the surgical field, in order to minimize the blind space at these times. The use of a 16 x 9 ("widescreen") picture aspect ratio also decreases the blind space on each side of the manipulated area.

Besides the decrease of *haptic* perception and the *fulcrum* effect, promoted by the motor interface, ports determine fixed angles defined at the beginning of the procedure, limiting the movements of the instruments in four degrees of freedom: the opening and closing of its jaw, rotation on its axis, swinging as it passes through the fixed point, and penetration and withdrawal of the instrument.

For good traction and better exposure of the viscera, the surgeon should learn to use gravity, and thus should have an operating table with a remote control that makes it possible to change the patient's position during surgery without interrupting the procedure.

Since the beginning of perceptual-motor adaptation surgeons should be warned that the preservation of the usual working conditions is extremely important. The centralized view should be maintained as much as possible, keeping a hand on each side of the viewing area (the situation experienced by human beings from birth). When both hands are working on one side of visual field, peripheral vision makes it difficult to sense and identify the active hand, but can be used on occasion, as long as movements are carefully executed. Working in a mirror view – when the direction of view is the inverse of the manipulation – is extremely complex and should be avoided. Therefore, the triangulation of the ports is critical for the maintenance of the centralized view. The instrumentation ports should be located on each side, permitting surgeon's right hand to work on the right of the area displayed on the monitor and the left of the left side.

Another triangulation should be respected. When exposing the viscera to be manipulated the assistant should pull the viscera to one side and the surgeon (or possibly the second hand of the assistant) to the other side, while gravity complements the triangulation. Thus the surgeon has at his disposal an suitable surgical field for safe handling.

The spatial orientation and navigation are skills that, fundamentally, depend on experiences during childhood; these skills are difficult to develop during adulthood. Childhood play, games, sports, and dance, as well as other physical activities are essential for the acquisition of a spatial sense and motor action in peripersonal space (spatial orientation and navigation). [19]

Another important issue related to the visual interface is that of *perceptual distortion* or *optical illusion*, often due to a phenomenon called perceptual constancy studied by aviators who use a different landing angle, depending on the geography surrounding the runway.[20] This may explain the greater number of biliary tract lesions with laparoscopic cholecystectomies, where the regional anatomy is seen from an angle entirely different from the conventional angle observed in open surgery.

Due to the static position for long periods and the awkward positions used by surgeons during laparoscopic surgery, a number of osteo-articular injuries, has been detected among the surgeons who perform these procedures.[21,22] It is important, therefore, to mention several ergonomic precautions such as: correct positioning of monitor, proper height of the operating table, types and sizes of the handles of the instruments that are appropriate for the size of the surgeon's hands, and even similar care with the placement of the foot pedals of the electric bisturi or other forms of energy, to minimize reaching during use that may cause misalignment of the spine.

To facilitate movement within the operating room, all the connections of the equipment to the electric circuitry, the connection of the camera to the monitors, tubes or hoses to conduct various types of gases should preferably descend from the ceiling. Changing the decubitus of the patient during surgery is absolutely necessary so that the force of gravity can provide traction on the mobile viscera (e.g. bowel loops) with consequent improvement of the operative field; hence the need for an operating table with a remote control. The measures described above should be present in an appropriate structure in order to provide ergonomic positioning for the entire operating team, promoting the comfort of all during the surgery, ensuring the safety of the patient and the team, and facilitating mobility within the operating room.

PERCEPTUAL-MOTOR ADAPTATION

Upon observing laparoscopic surgery training, the need for learning or relearning of some motor skills becomes evident. These skills should be understood as responsible for voluntary movements of the body in order to achieve goals acquired through training and practice, with the objective of attaining proficiency.[23]

Motor learning is reflected in the acquisition of consistency promoted by the repetition of the motor act until one attains automatization. According to psychologists Paul Fitts and Michael Posner, this adaptation can be divided into three steps or stages:

1. Initial (or cognitive) stage that is characterized by uncoordinated and inconsistent movements requiring a high degree of attention.

2. Intermediate (or associative) stage, when a small number of less serious errors occur that require less attention.

3. Advanced (or autonomous) stage, when there is greater consistency, combined with an agile skill, allowing the execution of simultaneous tasks.

At the end of these steps, when the movements become stable and precise, the learner reaches a *level of proficiency*. In this step, the motor actions become automated, no longer requiring greater concentration.

To attain this *level of proficiency* within an ethical standard, one cannot skip this adaptation period in humans. Therefore, there are some simulations where the environment is similar to that of the future patient when performing a laparoscopic approach. With the repetition of the motor act the *apprentice* will acquire consistency, reaching his goals more efficiently. Any introduction of new techniques or technologies functions as a disturbance, accompanied by the need for a new adaptive process for the reorganization of skills. [24]

Only after achieving the perceptual-motor adaptation can the *learner* be authorized to face the *learning curve* through the practice of each procedure to be performed. The motor training for laparoscopic surgery can be performed in fresh cadavers, in laboratory animals (especially pigs), and with simulators: inanimate (black box), biological, and virtual (with or without *enhanced reality*).

There is evidence of the effectiveness of training in virtual reality,[25] although it seems clear that the level of proficiency will be different among the surgeons and that some of the *trainees* will not able to acquire some motor skills despite the repetition of specific movements in virtual reality. [26,27] Surgeons experienced in video games, especially those who can achieve the best performances with this kind of game, have a greater facility in skipping the period of perceptual-motor adaptation in simulators. [28]

FINAL CONSIDERATIONS

Without a doubt the teaching of laparoscopic surgery can not follow the model developed and first implemented by William Halstead at Johns Hopkins Hospital in the late nineteenth century, when the surgeon would observe once, would perform on a second occasion, would be teaching at the third opportunity. The expression "*see one – do one – teach one*", used by so many, does not apply to the teaching of laparoscopic surgery.[29] With this new surgical approach there is an need to first adapt to a new work environment, where a perceptual-motor adaptation must occur, so that subsequently, at a later time, one can climb the *learning curve*, inherent with any new procedure.

The trail of technological achievements in *laparoscopic surgery* although exciting, requires a lot of dexterity and ability, besides requiring a great capacity for adaptation. It requires commitment and, above all, a certain humility to acknowledge and accept a new way of thinking and acting in the context of a new reality. This new approach to surgery requires dedicated training to allow for maximum ease in this new perceptual environment. In fact, we are striding step by step into the future, because going back to past is now inconceivable.

RESUMO

Diante de experiência com o Centro de Treinamento em Videocirurgia do Recife, respaldada por literatura específica, é analisada a fisiologia da percepção humana e as alterações de percepção, encontradas na cirurgia laparoscópica, sendo fornecidas orientações para facilitar o trabalho nestas novas circunstâncias perceptuais. Conclui-se pela necessidade de mudança na estrutura de ensino desta abordagem cirúrgica caracterizada por um período inicial de adaptação perceptivo-motora ao novo ambiente criado, seguido pela transposição da curva de aprendizagem de cada procedimento a ser executado.

Palavras chave: Aprendizagem. Percepção. Movimento. Cirurgia. Laparoscopia. Cirurgia video-assistida.

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